

Doctoral Thesis Evaluation Form

- 1. Name of PhD candidate / e-mail:**
Ing. Radovan Galas / Radovan.Galas@vut.cz
- 2. Name of PhD programme:**
Design and Process Engineering
- 3. Title of PhD thesis:**
Friction Modification within Wheel-Rail Contact
- 4. Title and name of principal supervisor/e-mail:**
Prof. Martin Hartl / Martin.Hartl@vut.cz
- 5. Title and name of co-supervisor/e-mail:**
Dr. Milan Omasta / omasta@fme.vutbr.cz
- 6. Title and name of reviewer/place of employment/e-mail:**
Prof. Dr. Raphael Pfaff / Schienenfahrzeugtechnik, FH Aachen University of Applied Sciences /
pfaff@fh-aachen.de
- 7. Overview of the scope of PhD thesis**

Evaluate using the following scale: very good
<p>The thesis under examination sets out to address the issue of friction modification for top-of-rail application in railway systems. As energy efficiency and environmental protection against noise are increasingly becoming a focus in railway and tram operation, such products become more interesting to operators and infrastructure managers alike.</p> <p>While studies in heavy haul operation exist, the thesis employs a combination of laboratory and field tests using a European tram operation to answer the following questions:</p> <ul style="list-style-type: none"> • What is the effect of quantity and composition of such products? • Can a save braking be ensured under overdosage? <p>In addition to the purely railway mechanical problems, the question of rail noise is also addressed. Laboratory trials using a ball-on-disc tribometer and a twin disc machine are executed and are able to provide an answer to the questions. The field test makes use of a tram system and multiple passes, it applies the braking distance as an indication of effect of the friction modifier as well as noise measurements.</p> <p>In a final series of laboratory trials, the effect of the individual ingredients as well the transporting agent (water) is investigated, which may be helpful in the design of specific friction modifiers.</p>

8. Significance of the topic and clarity of problem statement:

Evaluate using the following scale: good
<p>The author introduces his problem setting, his scientific questions as well his hypotheses very clearly. The reviewer appreciates the formalisation of the questions and hypotheses by numbering them for later reference in the argument. The problem, question and hypotheses statement is clear and concise.</p> <p>The topic of friction modification is very significant due to its high impact on operational performance, especially in conjunction with ATC systems. The reviewer expects that the knowledge of appropriately controlling the friction coefficient for a given stretch of track will rise even further in importance as soon as ETCS level 3 is operated, since in this way, individual trains may have their braking curve for the pass on the sprayed section.</p>

9. Knowledge of existing literature:

Evaluate using the following scale: very good
<p>The author provides a very thorough review of the topic itself as well as the relevant problems in railway maintenance and operation. These relevant problems not only include the obvious problems as corrugation and reduction of contact forces, but also the import topic of noise. Especially the review of third body layers in the wheel-rail contact is well researched and documented, as is the section on top of rail products.</p> <p>While the number of citations is less than average, the bibliography is well researched and curated, thus a very good basis for the further development of the argument.</p>

10. Choice of methods and technical soundness:

Evaluate using the following scale: very good
<p>The selected methods replicate the wheel rail contact problem in railways reasonable well, limitations are the scale of geometry and forces. This trade-off between scaling and possibility to execute a high number of trials is frequent and therefore the choice of the author is right. Not only the scaling is investigated, but also the used materials are analysed in terms of chemical and mechanical properties in order to gain insight into the comparability of the tests executed. Laboratory tests are performed on tribometers and a specifically designed twin disc machine. The twin disc machine is able to replicate the situation in a railway contact patch quite well, however an extreme angle of attack (for small tram radii) has been chosen. This choice is explained. As the laboratory experiments, the field tests aim on the situation of tramways. The braking distance measurements indicates the braking distance as well the slip situation, which is a good indicator of the performance. Further, multiple passes of the train were analysed.</p>

11. Quality, originality and significance of the results:

Evaluate using the following scale: very good
<p>The results were achieved with a rather high number of samples, even in the field test. This makes the results practically repeatable and valid.</p> <p>The reviewer is not aware of a combined laboratory and field test on the subject of top of rail products under European conditions, despite the interest in such products from European operators and infrastructure managers.</p> <p>While the results are interesting and manifest a novelty, the research is rather short of recommendations for the operator or infrastructure manager. This would help to make it even more valuable. A further shortcoming of the present work, which however is given as an indication for further research, is the exclusion of climatic effects. This will provide further practical value to the results.</p>

12. Quality of attached papers:

Evaluate using the following scale: very good
<p>Paper A presents a pure laboratory study. The paper is well written and structured. The methodology is well described, the results are interesting in relation to the hypotheses set out for the authors PhD thesis. The negative result of not being able to replicate saturation is taken care of in the following paper.</p> <p>Paper B makes use of the twin-disc machine as well as field measurements, which makes it valuable for the practitioner. It is also well written and structured. Shortcomings of this paper are that the potential negative results for the recommended amount of friction modifier from a brakes perspective, no improvement in sound level could be found and the lack of a recommendation.</p> <p>Paper C focuses more on the constituents of water based FM, which stronger addresses the underlying phenomena and the single substances. This may help to design specific friction modifiers for particular applications.</p>

13. Overall assessment, strengths and weaknesses (based upon the above evaluation categories 8–12):

Evaluate using the following scale: very good
<p>The thesis under review is a very well researched and structured cumulative thesis. The development of the topic from initial trials focusing on the amount via the field trials to the tests focusing on the individual constituents makes it very interesting. The strength of the research is the methodology and high number of trials as well as the evaluation of the data.</p> <p>Shortcomings of the thesis are minor, however include the absence of recommendations concerning the amount of friction modifier for the case under investigation and the extreme focus on tram operation. The wider scope, including mainline operation under modern ATC system, may have improved the strength and significance.</p>

14. Other comments:

Great work, should be integrated in a systems approach with e.g. braking curves as well as counteragents, e.g. sanding.

15. Conclusion:

PhD thesis is an independent scientific work that presents a novel solution to a significant problem in the research area and demonstrates the candidate's ability to conduct independent research.

Choose from following: YES

16. Date and signature:

31.1.2018

R. Pál

Please note

- A. Evaluate categories 8 to 13 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent. The qualification of 'excellent' should only be given for a PhD Thesis in the top 3% of the research in your field of expertise.
- B. In each category 8 to 13 explain reasons for evaluation using between 100–200 words.
- C. Overview of the scope of PhD thesis (Category 7) is a short description of objectives of PhD thesis's research and summary of main findings and scientific achievements.
- D. E-mail the completed form to: Klara.Javorcekkova@vut.cz